High resolution, fast and more informative LA imaging with the icpTOF

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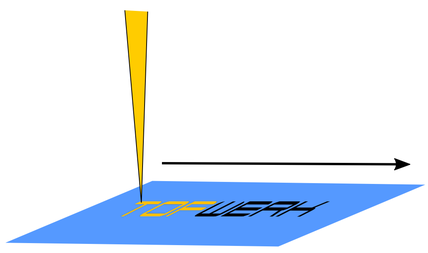
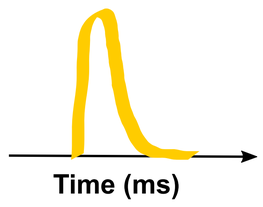
► Fast and high resolution imaging is of growing interest for many geological and biological applications, but poses challenges to laser ablation (LA) units and mass spectrometers (MS).
► Recently developed Dual Concentric Injector (DCI) from ESI [1] and Aerosol Rapid Introduction System (Aris) from Teledyne [2] as add-ons to the existing ablation chambers enable rapid aerosol washout of <50 ms and increase imaging speed and signal to noise ratio.
► To utilize these these new systems for multi-element imaging a mass spectrometer with high acquisition speed and simultaneous detection is required.
► This work demonstrates the coupling of TOFWERK time-of-flight mass spectrometer icpTOF with NRW 213 nm laser/TwoVol2 cell/DCI (ESI) and with Analyte G2 laser/Helix cell/Aris (Teledyne) for fast and easy imaging at high spatial resolution.

Imaging concept

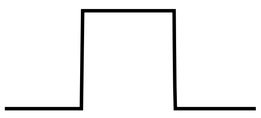
Contineous laser scan



Fast transfer of LA plume



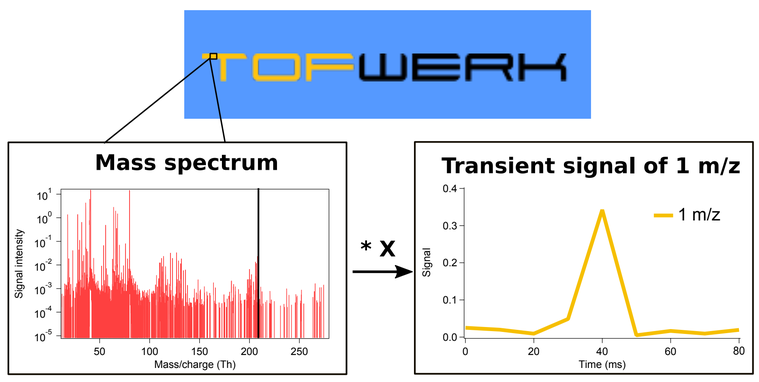
Trigger per pulse



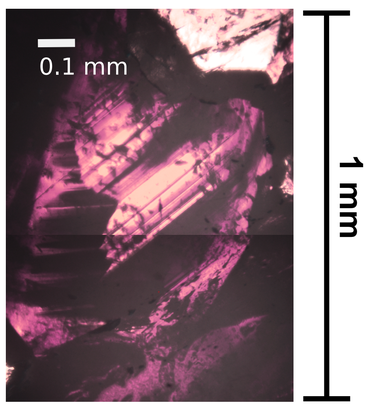
Synchronized detection of all m/z per pixel

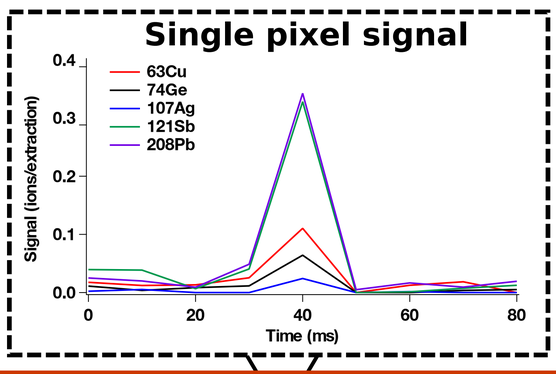
-Sensitivity comparable to ICP-QMS
-Full mass spectra at 33 kHz
-Linear response >1e6
-Mass resolving power >3000
-Interference removal with Q-cell
-Matrix removal with Notch filter
-External hardware triggering

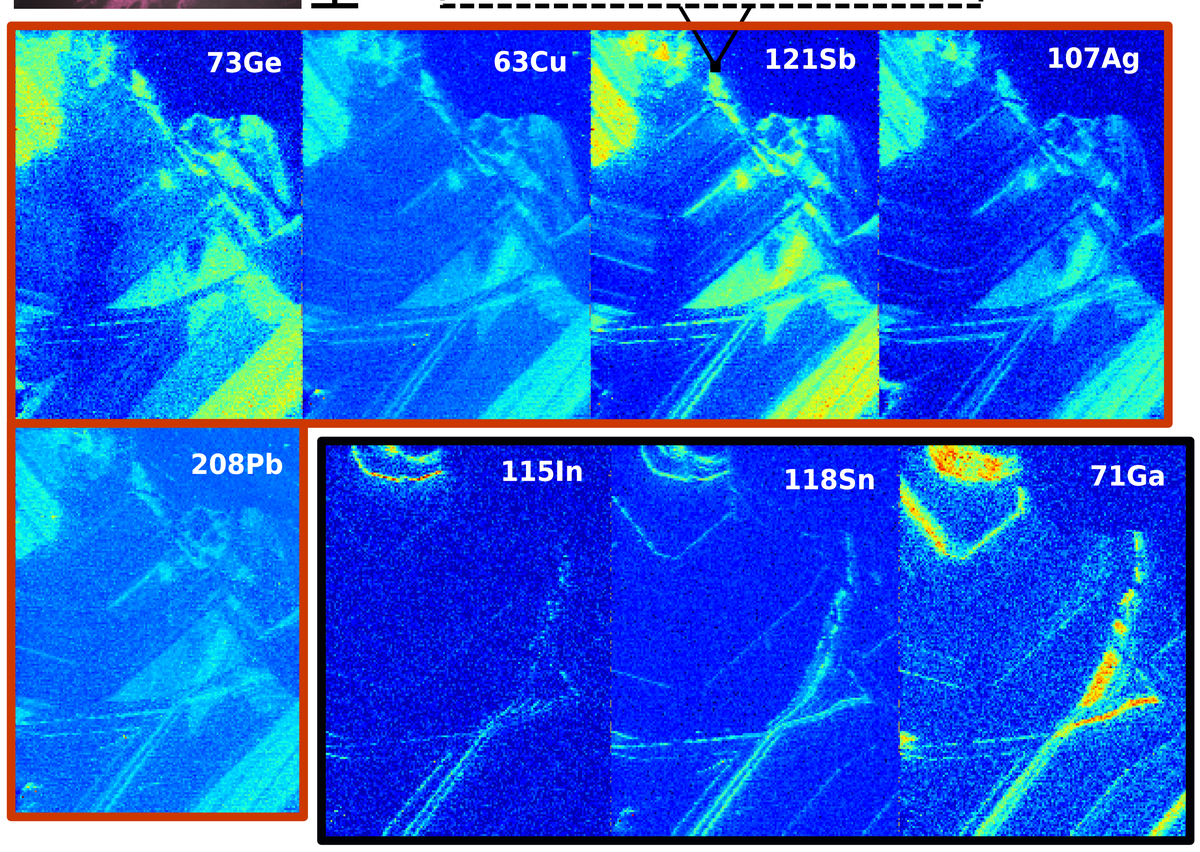
Pixel-resolved images of all m/z

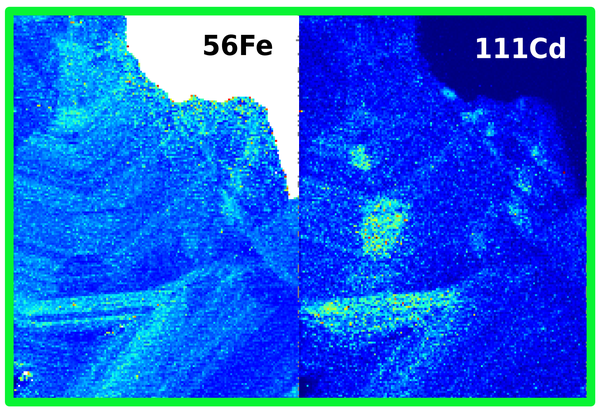


Sphalerite mapping with NRW 213/TwoVol2 cell/DCI



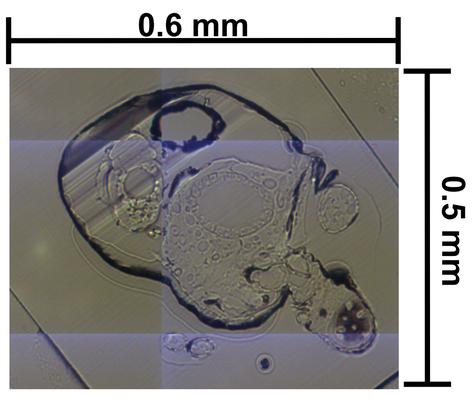


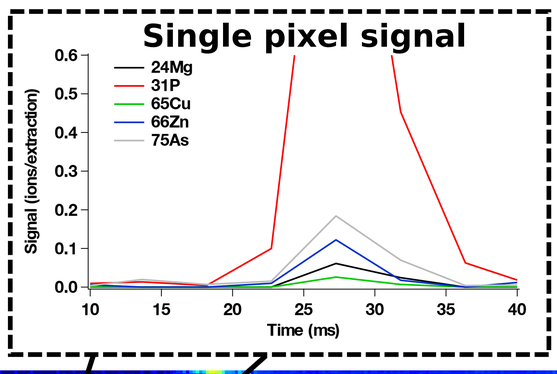


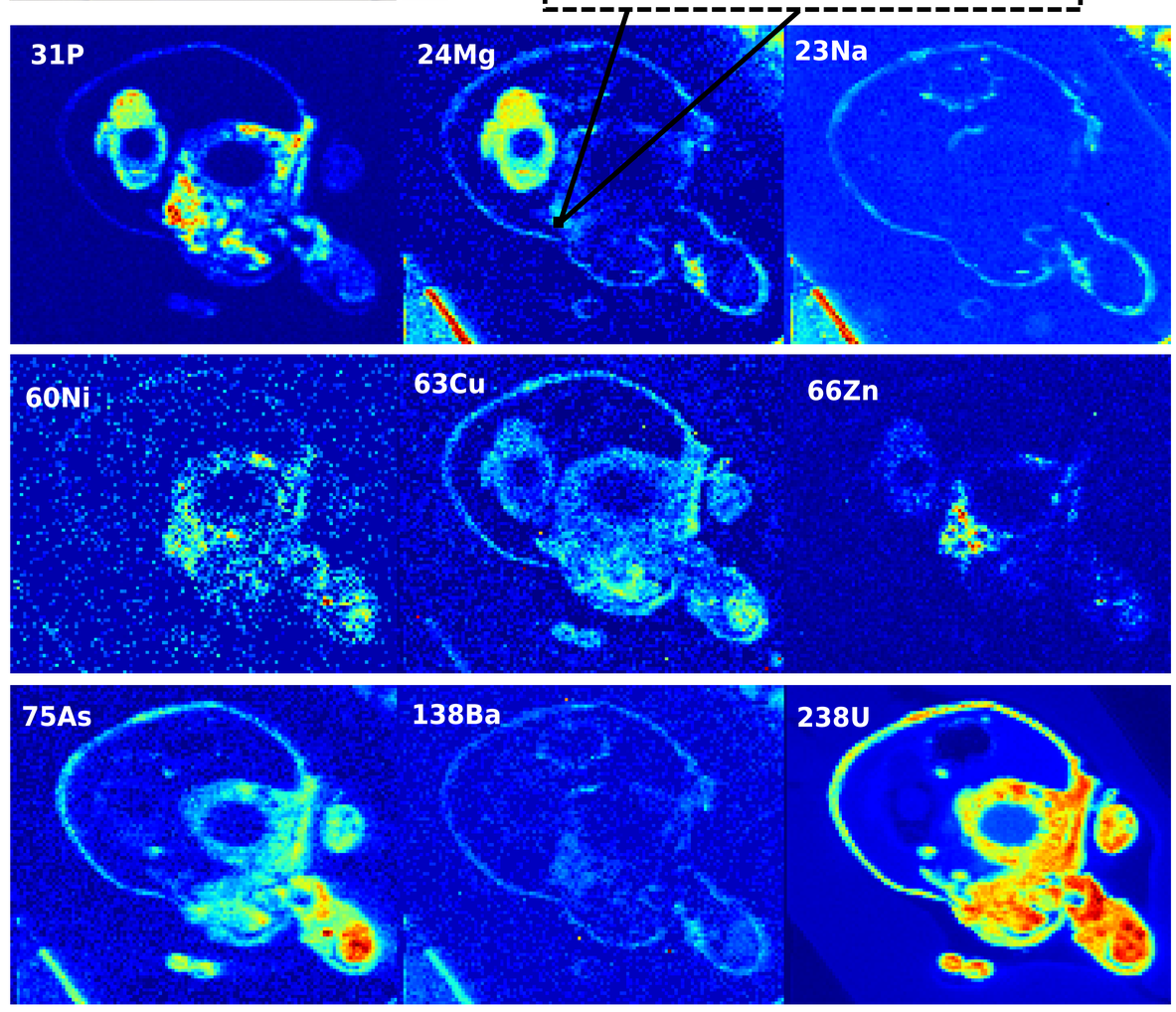


Optical and LA-ICP-MS intensity images of Ge-rich sphalerite. Using the icpTOF with the Dual Concentric Injector (ESI), an area of 750 µm x 1000 µm was mapped at 5-µm resolution in only 50 min, with seven complete mass spectra recorded for each 5-µm pixel. Ablation was performed at 10 Hz laser frequency, continuously scanning over lines at 50 µm/s. Each laser pulse produced a <100-ms transient signal, and adjacent pulses were easily resolved from one another. icpTOF acquisition was synchronized with the pulsing of the laser (one pulse/pixel). This sample was characterized in the previous study [3]. Different mineral zonings were measured at selected 60 µm and 32 µm spots and authors observed enrichment of Ge, Cu, Ga, Sb, and As in one zone and enrichment of Fe, Cd, In, and Sn in another. This high resolution image on one particular sample location provides more detailed information on elemetal correlation.

Ceriodaphnia imaging with Analyte G2/Helix cell/Aris







Optical and LA-ICP-MS intensity images of Ceriodahnia thin section. Using the icpTOF with the Aris (Teledyne), an area of 600 µm x 500 µm was mapped at 5-µm resolution in only 12 min, with five complete mass spectra recorded for each 5-µm pixel. Ablation was performed at 20 Hz laser frequency, continuously scanning over lines at 100 µm/s. Each laser pulse produced a <50-ms transient signal, and adjacent pulses were resolved from one another. icpTOF acquisition was synchronized with the pulsing of the laser (one pulse/pixel). Ceriodaphnia was exposed to Ni, Cu and Zn at concentrations close to concentration in contaminated river…..

Summary

► Rapid aerosol transfer systems resolve individual laser pulses at frequencies > 10 Hz, enabling sample scan at much higher speed than was earlier possible with standard configurations.
► icpTOF and laser synchronization on a single pixel basis simplify image reconstruction and provides sharp images with no pixel intermix.
► icpTOF measures several full mass spectra per every single pixel, providing higher information density about the sample.

Authors would like to acknowledge ESI and Teledyne for providing their laser ablation systems and for fruitful collaboration.

[1]
[2] D. N. Douglas et.al. Anal. Chem., 2015, 87, 11285-11294
[3] R. Belissont et.al. Geochimica et Cosmochimica Acta, 2014, 126, 518-540